EG&G Idaho, Inc.
FORM EG&G-2631 (Rev.11-87)

Project File Number ______
EDF Serial Number BWP-ISV-010
Functional File Number ______

ENGINEERING DESIGN FILE

Project/Task ISV Project
Subtask Intermediate-scale Test Design

Subject : INTERMEDIATE-SCALE ISV TEST REQUIREMENTS AND PIT DESIGN

Abstract : This EDF presents a test design for the intermediate-scale in situ vitrification (ISV) tests. The document contains: test objectives, test specifications, instrumentation/sampling considerations, test design, scaling considerations, and test acceptance criteria.

Introduction

In situ vitrification (ISV) is being considered as a long-term confinement technology for previously buried solid transuranic and mixed waste at the INEL Radioactive Waste Management Complex (RWMC). The ISV project will collect engineering data required to assess the suitability of the ISV process for use at the RWMC.

The technology assessment will rely on data collected during laboratory-, intermediate-, and full-scale testing. Previous laboratory-scale tests (Reference 1) have successfully vitrified INEL soils with high metal content, and provided technical justification for further development and scale-up of the ISV process for confinement of buried wastes at the RWMC.

The intermediate-scale ISV tests will more realistically represent performance of the full-scale system because of comparable processing times, and the lessening of scaling effects. The intermediate-scale testing is designed to provide additional data to assess the suitability of ISV at the INEL, by providing test areas of typical waste form, and areas containing reduced soil and high metal content.

This document specifies the test objectives and presents a test pit design to meet the objectives. During test pit construction and material preparation a log notebook will be kept and information recorded on construction details. Additionally, a photographic record of pit construction and filling will be made.

Distribution (complete package) J.L. Landon, B.L. Charboneau, D.M. LaRue, R.M. Schletter, J.F. Ginsberg

Distribution (cover sheet only): Project EDF file log, EDF serial no. log

Author	Dept.	Reviewed	Date	Approved	Date
R.A. Callow	ED00	R.M. Schletter	5/30/89	J.L. Landon	5/31/89

Purpose

The purpose of this EDF is to document the design of two ISV intermediate-scale tests (IS-INEL-1, -2) to be conducted at the INEL in FY-89. This EDF defines the test objectives, test specifications, test pit design, and acceptance criteria for these tests.

Test Objectives

Five major test objectives for the intermediate scale ISV test have been identified. These are:

(1) Verify the operational suitability of the electrode feeding system (EFS).

(2) Verify acceptable vitrification in a region containing waste forms similar to those expected at the Subsurface Disposal Area (SDA).

(3) Verify acceptable vitrification of a representative waste composition layer with minimum soil content.

(4) Verify acceptable vitrification of a waste layer with high metal content.

(5) Assess the potential for radionuclide transport during the vitrification process by using a non-radioactive simulant.

(6) Obtain engineering and scientific data necessary to assess the engineering capability of the ISV systems, safety of the process streams, and the suitability of the process as a remedial method.

Each of these objectives is justified as follows:

(1) Operational suitability of the EFS. All previous ISV tests have been conducted with the electrode fixed at their maximum depth in

the ground in pre-drilled holes. The electrode feed system is being designed to allow the melt to be started with the electrodes inserted in shallow (< 18") holes in the ground. As the melt progresses, the electrodes will be fed down to their desired depth. This method of operation (no pre-drilling) is highly desirable to reduce contamination spread and exposure at radioactive sites such as the SDA. The suitability of the electrode feeding system will be demonstrated at the intermediate-scale before a full-scale EFS is designed and built.

(2) Verify vitrification in a region containing waste forms similar to those found in the SDA. It is necessary to demonstrate the suitability of the ISV technology in producing acceptable vitrified product from soil and waste forms like those found in the SDA. Where applicable, information from SDA Pit 9 will be used as representative; however it is recognized that there is significant uncertainty and variability regarding waste composition throughout the SDA.

(3) Verify vitrification of a waste layer with minimum soil content. Stacking of boxes and drums in areas of the SDA could result in waste layers with reduced amounts of soil. It is necessary to verify that the technique will provide suitable vitrification in these situations.

(4) Verify acceptable vitrification of a waste layer with high metal content. Areas of high metal content can potentially result in the formation of a metallic pool layer with subsequent shorting of the electrodes. It is necessary to verify the suitability of the ISV/EFS technique under such circumstances since large metallic objects and areas of high metallic content may occur in the SDA.

(5) Assess the potential for radionuclide transport. The intermediate-scale test presents an opportunity to assess the behavior of radionuclides by using non-radioactive, non-hazardous simulants. Potential problems can be identified and addressed

prior to full-scale testing in radioactively contaminated waste.

(6) Obtain engineering and scientific data necessary to assess the suitability of the technology. It is necessary to collect data which will allow assessment of the engineering, safety and environmental acceptability of the ISV process when applied at the SDA. Data which may be applicable for the decision-making process assessing ISV as a remediation method will be collected via guidelines provided in the Sampling and Analysis Plan. In addition, engineering data will be collected to be used for making modifications to the large-scale system to improve performance.

Test Specifications

The test will be designed to the following specifications:

(1) Provide a soil overburden layer for melt initiation and performance of the Operational Acceptance Test for the Electrode Feeding System. The minimum overburden depth will be 18 inches.

(2) Provide a layer with waste forms similar to those present in the SDA. A layer will be provided which contains randomly dumped drums and boxes and fill dirt. The drums and boxes will contain waste composition fractions similar to fractions expected to occur within the SDA. The ratio: waste volume/total volume will be representative of the disposal efficiency within the SDA. Details concerning waste composition fractions are provided in a subsequent section.

(3) Provide a layer with minimum soil content. Minimum soil content will be simulated by a region containing stacked drums. It is anticipated that the stacked drum layer will contain approximately 20% soil (volume basis); data on soil amount will be collected during pit construction.

(4) Provide a layer with high metal content. High metal content can

be simulated by a region containing boxes filled with scrap metal and fill dirt. (This represents a waste layer expected to be found throughout the SDA.) The metal added in the layer will be adjusted to obtain an approximate target value of 12 wt% for the region expected to be vitrified. This target value refers to the percent of metal relative to the total mass (waste and soil). This value is based on information in Reference 7 which estimated a maximum local metal content in Pit 9 of 10 wt%.

(5) Provide for the depth and radial measurement of the melt growth. Accuracy within 1 ft is sufficient.

(6) Provide for a non-hazardous plutonium simulant to evaluate the potential for plutonium migration in the soil, carryover into the off-gas system, and distribution within the vitrified product.

(7) Provide sampling collection sufficient to allow assessment of the ISV technology with respect to safety and environmental concerns at the SDA. More detailed sampling objectives are provided below.

<u>Sampling Considerations</u>

The intermediate-scale ISV test is part of an overall treatability study to determine the applicability of the ISV technology to the INEL site. A top level objective of the study is to provide sufficient data to allow treatment objectives to be fully analyzed and evaluated. Additional ISV Project objectives include data collection necessary to ensure compliance with health, safety, and regulatory requirements.

Sampling tasks will be developed to provide information to assess the ISV technology regarding engineering performance, safety, and environmental acceptability. Of particular importance are data needed to assess the following:

- o Potential for radionuclide migration from the region of vitrification.
- o Potential for radionuclide concentration in the vitrified

glass.

- o Ability of the off-gas system to process off gases and reduce emmisions to allowable levels.
- o Durability of the vitrified waste form to ensure acceptable long-term confinement of radionuclides.

Based on these considerations, sampling for the intermediate-scale ISV test will include the following:

- o Pre-test soil sampling. Pre-test soil sampling will be conducted to measure soil characteristics and background levels of the rare earth tracer used to simulate plutonium.

- o Post-test soil sampling. Post-test soil sampling will be conducted to measure post-test concentration of the rare earth plutonium simulant.

- o Vitrified glass sampling. The vitrified product will be sampled and tested for tracer concentration, product strength, and leach characteristics.

- o Off-gas scrubbing liquid. The off-gas scrubbing solution will be sampled and analyzed for tracer concentrations.

- o Temperature gradient. Temperature gradient will be monitored to provide a continuous record of melt growth in the ground.

- o Vitrification boundaries (can be post-cooldown). Measurement of vitrification boundaries will allow assessment of whether the process produced acceptable melt depth and width.

- o Stack monitoring. The stack gas will be monitored to measure tracer concentrations.

Details of the sampling methodology will be provided in the ISV

Intermediate Scale Sampling and Analysis Plan.

Radionuclides and Hazardous Chemicals

The intermediate-scale test pits will not contain any radionuclides or hazardous chemicals. In order to simulate plutonium, the pits will be spiked with one or more rare earth tracers to be defined in the Sampling and Analysis Plan. The potential for plutonium migration will be assessed by measuring for tracers in the off-gas system, and in the soil surrounding the vitrified block. Additionally, measurements of tracer concentration profiles in the vitrified block will be conducted.

No volatile organics will be added to the test pits. Measurements of organic migration will be conducted in controlled conditions during laboratory testing.

The exclusion of radionuclides is expected to have little effect on vitrification process parameters. However the exclusion of volatile organics is recognized to be a compromise. Vitrification process parameters may be different in areas of the SDA where organics are present. Data from laboratory testing will be used to assess potential areas of difference.

Scaling Considerations

The intermediate-scale ISV test pits will be scaled representations of the SDA. Test pit scaling is necessitated by the reduced electrode spacing and power output for the intermediate-scale ISV system as compared to the large-scale system.

Pacific Northwest Laboratories (PNL) has provided recommended values for electrode spacing for the intermediate-scale (3.5 ft recommended spacing) and large-scale (11.5 ft recommended spacing) ISV systems. The large-scale recommended electrode spacing was derived from a computer model (Reference 4) which indicated this spacing as sufficient to provide a melt depth of 20 ft in INEL soil. The intermediate-scale recommended value for electrode spacing was scaled from the large-scale spacing in order to provide equal power density (kW/m^2) to the melt at each scale.

The waste containers used in the intermediate-scale test will be scaled representations of 55 gal drums and 4 ft x 4 ft x 8 ft boxes. The linear dimensions will be reduced by the ratio of the electrode spacing (3.5/11.5). Therefore the volume of waste containers will be reduced by $(3.5/11.5)^3$. Standard available containers with volumes closely approximating the calculated scaled volumes will be used.

Other waste forms included in the test pits will be reduced in size by the ratio of electrode spacing. Specifically, the largest metal object length will be approximately 2.5 ft based on an approximate maximum length of 8 ft in a full-scale box.

Waste Fractions and Disposal Efficiency

The solid radioactive waste stored at the SDA is composed of trash, including: broken equipment, lumber, paper, rags, plastic, and other solid debris. Substantial amounts of organic wastes from the Rocky Flats Plant exist in several pits, including Pit 9.

Significant uncertainties exist regarding the distribution of waste throughout the SDA. The intermediate-scale test pits will be designed to include waste fractions similar to those found in the SDA as determined from several sources of information. Waste fractions of drums and boxes are obtained from Reference 2. (These fractions are the same as those used in constructing the full-scale cold pit described in Reference 3.) The waste fractions for drums and boxes (on a volume basis) are as follows:

For drums:

Sludge	0.30
Combustibles	0.50
Metals	0.08
Concrete/asphalt	0.10
Filters/wood/glass	0.02

For boxes

Metal	0.80
Concrete/glass/ asphalt/wood	0.20

Separate waste materials will not be mixed within individual drums, ie. 50% of the drums will consist of entirely combustibles, 30% of entirely sludge, etc.

The metals used will be carbon steel and stainless steel. An approximate 50/50 ratio of carbon and stainless steel will be used.

An important parameter of concern for the ISV process is that of disposal efficiency, the ratio: waste volume/total volume. (The same information can also be expressed in terms of soil-to-waste ratio.) The relative amounts of soil and waste are important for vitrification because the process must have suitable amounts of soil to maintain conductance to the melt. The soil-to-waste process limitations have not been defined for the ISV technology; therefore the performance of the ISV process under SDA-representative disposal efficiencies needs to be assessed. For Pit 9, a reasonable estimate of disposal efficiency is 0.25 (Reference 5); however this is an average value for the entire pit. In local areas such as a stacked drum or box region the disposal efficiency could be significantly higher.

The two intermediate-scale tests defined in this EDF will test the ISV technology in regions of different local disposal efficiencies. Because the intermediate-scale waste forms are scaled, results of the tests will provide information for assessing full-scale ISV performance. The disposal efficiencies in the two test regions will be representative of disposal efficiencies in similar regions of the SDA.

Sludge Composition

Significant amounts of organic wastes contained in 55 gal drums from the Rocky Flats Plant are buried in Pits 5, 6, 9, and 10. Much of the sludge buried in Pit 9 consists of Organic Setups, Content Code 3 as described in Reference 6. As indicated above, hazardous organics will not be added to the test pits. Therefore the test pit sludge materials will consist of absorbent materials minus the organics. To represent Content Code 3 sludge, the appropriate amounts of calcium silicate and Oil-Dri (trade name) will be added to the containers; water will be substituted for the organic volume in order to provide a more realistic amount of vapor release into the off-gas system.

Test Pit Soil Material

The test pits will be excavated to 10 ft depth. The bottom of the pits will be backfilled with soil to the desired depth for the individual test. The waste forms will be placed on top of the backfilled underburden. The soil used for underburden and the soil used as backfill during pit construction will be transported from near the SDA if it is determined from soil sampling and analysis that soil characteristics at the test pit location are significantly different from lakebed soil used for fill at the SDA. The decision to transport soil will be based on soil characteristics of importance to the ISV process. This decision will be made by the Project Manager in conjunction with PNL personnel.

Test Design

This section provides the test design for the two intermediate-scale test pits. The pit designs are based on meeting the specified test objectives. During the fabrication of waste containers and the filling of the pits a notebook will be kept which details the actual as built construction. In addition a photographic record will be kept. Any deviations from the proposed pit design will be recorded in the notebook. Additional data to be recorded includes: individual waste container contents and weights, placement of containers in stacked regions, overall estimates of fill dirt added to the pits, and procedures used during pit construction such as soil compacting.

Two intermediate-scale tests will be conducted. The first test will be designed to provide for the electrode feed system Operational Acceptance Test and demonstrate system performance in a layer with waste form composition similar to that found in the SDA. The second test will demonstrate system performance in a layer with minimum soil content and in a layer with high metal content. It is not intended that the first test present major challenges to the ISV technology from the standpoint of waste forms. It is crucial for all test objectives that the electrode feeding system perform acceptably. If the EFS performs well, it is not anticipated that the INEL soil and representative waste forms will present conditions unsuitable for vitrification by the process.

The second test will provide conditions under which the ISV process has not been previously challenged. However these conditions are reasonable in light of past disposal practices at the SDA.

Figure 1 shows the test pit for Test 1. The surface linear dimensions of the pit will be a minimum 10 ft x 10 ft to provide a width margin for the test. Pre-test calculations predict a melt diameter of approximately 7 ft. In the vertical direction two feet of soil will be placed over approximately 6 ft of a scaled, representative soil/waste mixture. The 2 ft soil overburden represents an approximate scaled depth based on the estimated 6 ft overburden depth for Pit 9 of the SDA (Reference 5). Vitrification of the top layer of soil will be performed during the operational acceptance test for the electrode feeding system. The waste layer will consist of a randomly dumped mixture of waste containers and fill dirt. The waste proportions are provided above. The test pit waste region (10 ft x 10 ft x 6 ft) will contain approximately 208 drums and 20 boxes. The drums will be 2 gal steel and the boxes will be approximately 30 in x 18 in x 18 in. The ratio of drums to boxes will be the same used in the random dump zone of the full-scale cold pit described in Reference 3.

The number of drums and boxes placed in the pit will provide for a disposal efficiency of 25% within the waste layer. The data for construction of the cold TRU test pit (Reference 3) indicate a disposal efficiency of 25% within the random-dump waste layer. The overall disposal efficiency for Pit 9 is estimated to be approximately 25% inclusive of overburden (Reference 5).

The 2 ft soil underburden provides a margin of representative soil for vitrification if the predicted depth is exceeded.

Figure 2 shows the proposed test pit for Test 2. The surface linear dimensions of the pit will be a minimum 10 ft x 10 ft to provide a width margin for the test. Pre-test calculations predict a melt diameter of approximately 7 ft. In the vertical direction a top layer of 2 ft soil will be placed over several layers of waste form. The 2 ft soil overburden represents an approximated scaled depth based on the estimated 6 ft overburden depth for Pit 9 of the SDA (Reference 5). Waste materials and containers will be scaled. Drums will be 2 gal steel and boxes will be approximately 30 in x 18 in x 18 in. From 2 ft to 4 ft, a stacked drum region of representative waste material will be placed. This region will contain small amounts of soil contained within interstitial spaces between the drums. The drums will be stacked horizontally, in a layer approximately 2 to 3 drums high. Approximately 504 drums are expected to be placed in the pit. The region from 4 ft to 7 ft will consist of a region of boxes filled with metal. Approximately 48 boxes (30 in x 18 in x 18 in, and stacked two high) will be required. These boxes will have dirt filled into the void spaces not occupied by the metal scraps. The upper layer of boxes will contain an amount of metal calculated to provide an overall metal content of 12 wt% to the 5.5 ft depth. As indicated previously, this is intended to be a reasonable value for high metal content based on information in Reference 7.

The 3.5 ft soil underburden provides a margin of representative soil for vitrification if the predicted depth is exceeded. Excess underburden is provided to test whether a region of high metal content may promote downward growth of the melt.

Container Materials

The scaled drums (approximately 2 gal volume) will be steel. The use of steel drums may result in a greater challenge for the ISV process than would be encountered in Pit 9 of the SDA. The greater challenge results from the larger potential for electrical shorting problems with new metal drums than may exist with oxidized metal drums in Pit 9. However inspection of available photographs from earlier SDA excavation projects indicates that drums appeared to retain structural integrity in a stacked drum region even after 20 years of burial. Based on existing information, the use of scaled metal drums presents a reasonable, though conservative, model for conditions in a Pit 9 stacked drum region.

The scaled boxes will be cardboard. Both cardboard and wood boxes were buried in Pit 9.

Test Acceptance Criteria

Test 1

Demonstrate vitrification to a minimum 6 ft depth.

Satisfy Operational Acceptance Criteria for the electrode feeding system. (These criteria to be developed by PNL.)

Test 2

Demonstrate vitrification through the layer with minimum soil.

Demonstrate vitrification through the layer with high metal content.

Both Tests

Hood pressure maintained between 2 in. water (vacuum) and 1 in. water (positive pressure).

Depth progression can be measured to a accuracy within 1 ft, independent of thermocouple data.

Electrode shorting or loss of conduction path shall not prevent vitrification to a minimum depth of 6 ft.

References

1. K.H. Oma, et al., Support for the In Situ Vitrification Treatability Study at the Idaho National Engineering Laboratory: FY 1988 Summary, Pacific Northwest Laboratory, PNL-6787, February 1989.

2. J.O. Low, Annual Technology Assessment and Progress Report for the Buried Transuranic Waste Program at the Idaho National Engineering Laboratory, EGG-2429, December 1985.

3. G.G. Loomis, Design and Construction Details of the INEL Simulated TRU Test Pit, Engineering Design File BWP-ISV-009, March 1989.

4. J.L. Buelt, et al., In Situ Vitrification of Transuranic Waste: An Updated Systems Evaluation and Applications Assessment, PNL-4800, Supplement 1, March 1987.

5. K.P. Guay, Preparation of Soil Distribution in Trenches 1-10, and Pits 1-6, 9, and 10, Engineering Design File BWP-ISV-011 (Draft), April 1989.

6. T.L. Clements, Jr., Content Code Assessments for INEL Contact-Handled Stored Transuranic Wastes, WM-F1-82-021, EG&G Idaho, October 1982.

7. E.C. Garcia, et al., Estimate of Metal Content of SDA, Engineering Design File BWP-ISV-005, January 1989.

FIGURE 1

TEST 1

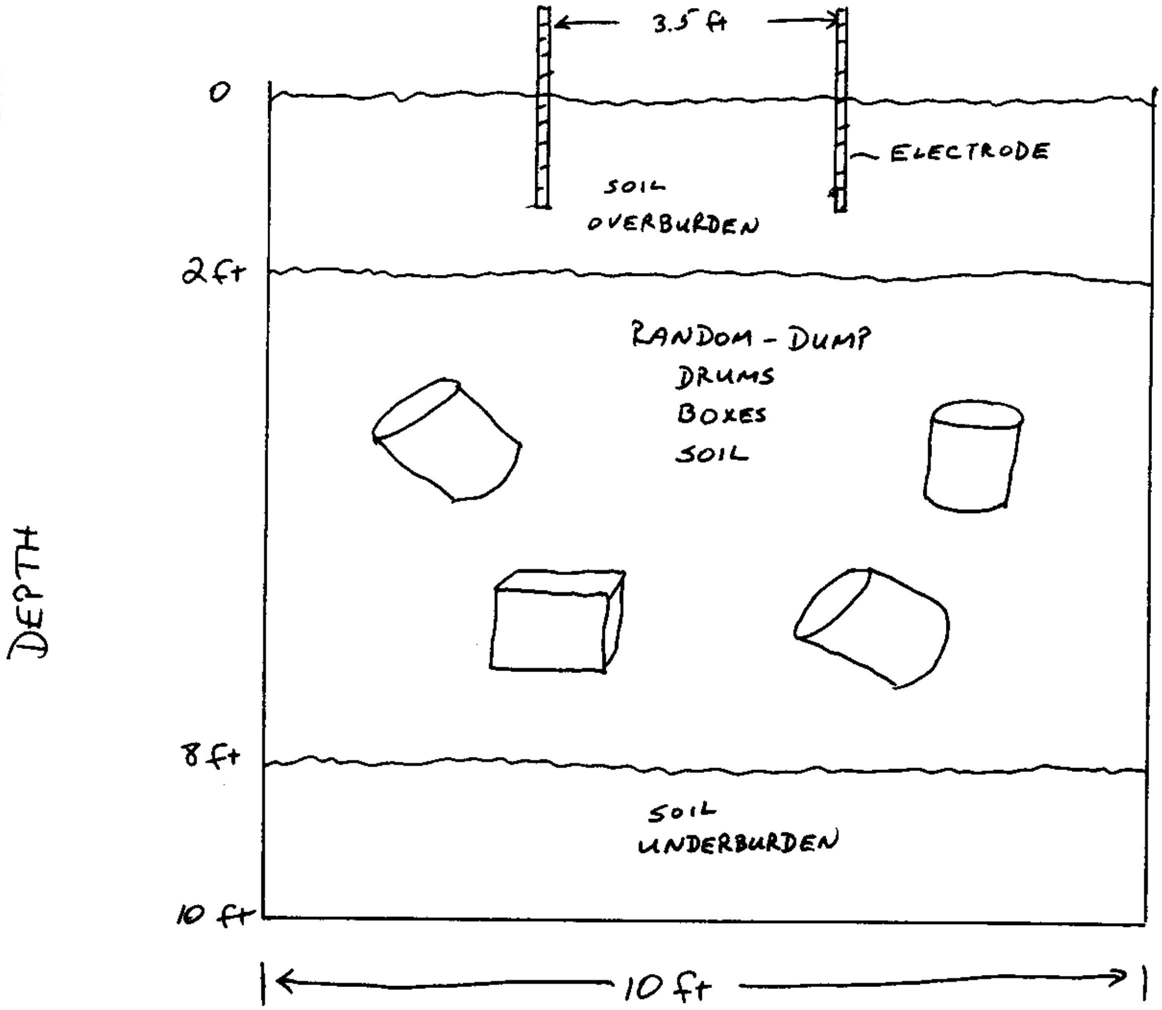
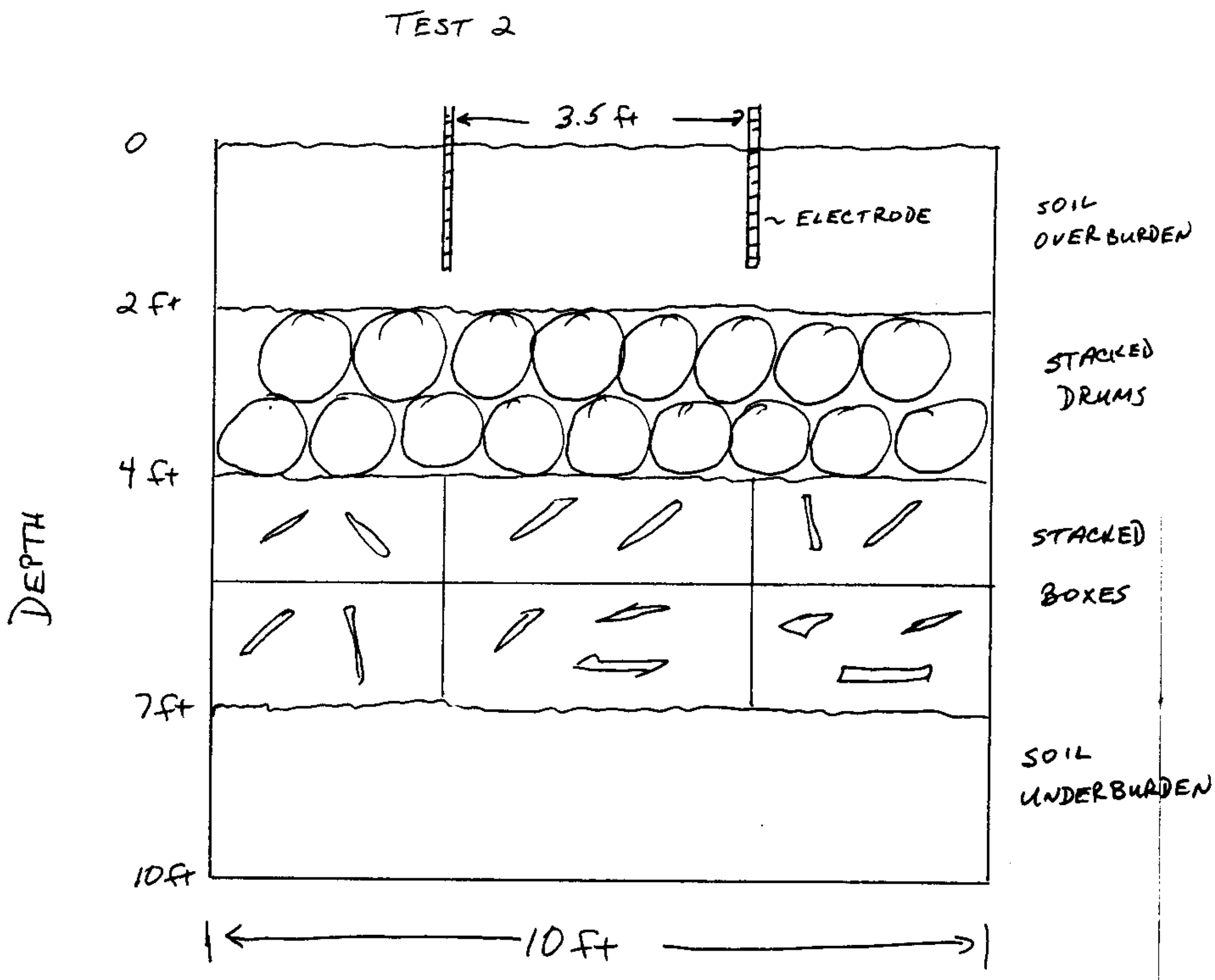


FIGURE 2


TEST 2
3.5 ft
0
ELECTRODE
SOIL OVERBURDEN
2 ft
STACKED DRUMS
4 ft
STACKED BOXES
DEPTH
7ft
SOIL UNDERBURDEN
10ft
10 ft